JUSTIFICATION FOR OTHER THAN FULL AND OPEN COMPETITION (JOFOC)

1. **This document is a justification for other than full and open competition prepared by NASA Goddard Space Flight Center (NASA's GSFC).**

2. **The nature and/or description of the action being approved:**

   This justification provides the rationale for contracting by other than full and open competition for the acquisition of technical support and development efforts related to the delivery of microchip Yb:YAG monolithic multi-element laser transmitters and avalanche photo-detector (APD) arrays with readout integrated circuitries (ROIC) on hardware suitable for the Instrument Incubator Program (IIP) entitled "Efficient Swath Mapping Laser Altimeter Demonstration." This IIP is a technology demonstration that is applicable to an anticipated Ladar Surface Topography (LIST) mission between 2016 and 2020.

3. **Description of the supplies or services required, include an estimated value:**

   This requirement is for technology development and hardware delivery of a high efficient (>15 percent electrical-to-optical) Yb:YAG microchip laser, monolithic multi-element microchip Yb:YAG laser array, APD with ROIC and multi-element APD array with ROIC components and systems for the IIP over a 3-year period. NASA's GSFC proposes to enter into a Cost-Plus Fixed-Fee Indefinite Delivery Indefinite Quantity contract [redacted]

4. **Statutory authority permitting other than full and open competition:**

   This statutory authority is 10 U.S.C. 2304 (c) (1), Only One Responsible Source.

5. **A demonstration that the proposed contractor's unique qualifications or the nature of the acquisition requires use of the authority cited:**

   Raytheon has developed the Laser Radar (LADAR) system that will be used for the IIP, with a goal of field demonstration at Year 3, a non-scanning 3-D imaging LADAR system using multi-element (4x4) Yb:YAG monolithic microchip lasers as the source to illuminate a 2-dimensional landscape. The height information (the 3rd dimension) is obtained by doing time-of-flight measurement of the illumination light pulses. A receiver telescope will capture the return light and image onto a perfectly matched 4x4 multi-element APD array with ultra-low noise ROIC to process the captured data. This system does not require any scanning mechanism to reduce risk to the system reliability.

   Raytheon is uniquely qualified for this task because of their innovative technical approaches in producing high efficiency (>15%) Yb:YAG microchip lasers and the highest quantum

efficiency (>95%) at 1030 nm with the lowest noise APD arrays coupled with ultra low noise ROIC.

In Year 3, the LADAR must fly and demonstrate the technology on an airplane in order to prove the design and approach are sound and ready for space application. The Government is considering using a Global Hawk or a Lear jet as the carrier. The power available on the airplane is limited and needs to have a high electrical-to-optical conversion efficiency laser for the instrument greater than 15 percent. Typical solid state lasers have wall plug (electrical-to-optical) efficiency of under 4 percent. The prime power requirement from the spacecraft or aircraft must be approximately 25W for a 1W average power laser system. A 15 percent electrical-to-optical efficiency means that a reduction of >4 units is now possible. To produce a 1W optical power laser, the prime power requirement is now only <7W. Thus during the 3rd year of the IIP when we need to demonstrate the performance of the LADAR system, a smaller airplane can be used to lower cost and resources. The objective of this IIP is to advance the technology readiness level (TRL) of the proposed technology for a future space flight mission. It is proposed to advance the TRL of the laser and detectors from 3, the analytical and experimental critical function to 6, the system/subsystem prototyping demonstration at the end of Year 3. Imposing the 15 percent requirement at this time is critical to meet the program objectives for airborne demonstration and future space flight requirements.

Raytheon has already demonstrated extremely high average output power in 1-3 ns pulses at 10-30 kHz at typical beam qualities of near diffraction limited with an unprecedented electrical efficiency of 15 percent. The Government has conducted extensive market research as well as published a sources sought synopsis (Solicitation Number: NNG0725329R; Titled: Component Technologies for Topographic Mapping) on September 3, 2008. Market research confirmed that Raytheon is the only vendor that provides both laser and detector components meeting this specification. In addition, no responses were received from the published synopsis. Raytheon has designed a family of short pulse, high rep rate, high efficiency, moderate power lasers, primarily as a source for space based LADAR applications. This type of laser is a direct extension of a self funded Space Qualified Laser effort that included extensive development and testing of a monolithic Microchip Oscillator (MCO) laser source over the past 3 years, as well as over 15 years of Raytheon experience in the diode pumping of Yb:YAG lasers.

This is a 3-year program with an extremely aggressive schedule to demonstrate and field test a LADAR system. To meet the stringent time schedule, we require a vendor that has a strong knowledge base and most importantly, a proven and demonstrated approach to minimize development time is required. Other companies doing work in this area may be able to produce single element Yb:YAG microchip lasers but not equal to the >15 percent efficiency rate provided by Raytheon. In Year 2 of the IIP program, we will demonstrate a multi-element Yb:YAG microchip laser array. This is a monolithic design in which 4 laser elements are made up of a single crystal with proprietary processing and fabrication techniques championed by Raytheon. This design allows for closely packed laser elements and is 100 percent compatible to their proprietary planar waveguide amplifier design which can be used to scale up the power for higher altitude flight or space flight use. This

monolithic design is patented and other companies cannot offer the form, fit, or function that is proposed by Raytheon. This is a requirement for the airborne test so opto-mechanical alignment of the multi-element laser array is minimized and the configuration of the array is 100 percent matched to the detector array configuration for system level testing. The successful demonstration of linear-mode single photon-counting 4x4 and 8x8 arrays is a first in the industry and puts Raytheon in a unique position to meet NASA "Efficient Swath Mapping Laser Altimetry Demonstration" requirements with low cost and minimal risk.

Raytheon and its legacy companies (Hughes Aircraft, Texas Instruments, E-Systems) have an extensive history of cutting edge laser and LADAR system development stretching back over 48 years to the very first laser and laser rangefinders, as well as the first Military Qualified LADAR, for the Advanced Cruise Missile. They have delivered over 40,000 laser systems for rugged military, airborne, and space environments and continue strong investments in research and development into these technologies.

One of the key subsystems of this IIP is the hybrid integrated focal plane array (FPA). It consists of a 2D APD array hybridized to a low-noise and high-speed ROIC (< 1 pA/rt-Hz). Raytheon has been developing advanced Mercury Cadmium Telluride (HgCdTe) APD arrays and high performance ROIC for scanning and staring LADAR systems under Department of Defense (DoD) and the Defense Advanced Research Projects Agency funding for more than a decade and is the leading company in development of new FPA technologies for both NASA and the DoD.

Raytheon has developed a proprietary process to manufacture APD detector array with >95 percent quantum efficiency (QE) and ultra low noise ROIC (< 1 pA/rt-Hz). The >95 percent QE detector array is a necessary requirement. The higher the detector sensitivity, the lower the laser power is required to make the measurement. Since the Government will be doing photo counting using this detector, high QE and low noise are both required. Raytheon's approach to APD design utilizes a vertical architecture called a Separate Absorber Multiplication (SAM) design. The SAM architecture enables separate optimization of low noise gain and high QE (> 95 percent) spectral absorption with a suitable anti-reflection coating. No other vendor can match the performance and the low noise level of Raytheon's APD array with ROIC. Raytheon has been fabricating large format detector arrays for various DoD programs. More importantly, Raytheon has recently demonstrated the performance and functionality of linear-mode single photon counting 4x4 and 8x8 APD arrays as part of the Ultra Sensitive Detection Program sponsored by DoD. The IIP is to support the LIST mission. The intent of the mission is to map the Earth with multiple spots aligned in a linear format. The measurement technique and technology demonstration will be: (1) demonstrate how to generate a multi-beam pattern; (2) use the multi-beam pattern to project the beam pattern on the ground so the reflected beams can be collected and imaged onto a detector array; and (3) resolve temporally the return beam pulse and retrieve through the it's propagation path.

In addition, Raytheon has routinely achieved, through design and fabrication, radiation-hard levels over 250 krad appropriate for long life space missions. Raytheon has extensively characterized radiation effects; developed processes to prevent surface inversion and circuit

design architectures that maintain linear operation over a range of radiation induced shifts in device electrical characteristics and minimize proton induced degradation. These capabilities are very important for putting the swath mapping altimeter in place as part of the LIST mission in the near future.

Raytheon's unique high efficiency Yb:YAG microchip laser and one-of-a-kind APD detector technologies are unmatched by any vendor in the world. As such, Raytheon is the only company able to offer the Space Traceable MCO laser source, the APD detector technology and the space packaging and testing experience required by NASA Goddard to succeed in the NASA IIP - Efficient Swath Mapping Laser Altimetry Demonstration. Again, while there are other companies that are performing similar work, Raytheon is the most advanced and best qualified to meet our development need.

6. **Description of the efforts made to ensure that offers are solicited from as many potential sources as practicable, including whether a notice was or will be publicized as required by Federal Acquisition Regulation (FAR) 5.202:**

   Notice of this intent to award a noncompetitive contract to Raytheon was advertised in Federal Business Opportunities on September 3, 2008. No responses were received to that notice.

7. **A determination by the contracting officer that the anticipated cost to the Government will be fair and reasonable:**

   The Contracting Officer will conduct a cost and price analysis to determine that the propsed prices will be fair and reasonable. We have also performed an in-house estimate that will be used to evaluate the proposal for fair and reasonable costs.

8. **Description of the market survey conducted, and the results, or a statement of the reasons a market survey was not conducted:**

   To our knowledge, Raytheon produced the ytterbium YAG based microchip the single element laser and mutli-element monolithic Yb:YAG microchip laser array that has the best electrical efficiency (15 perecent) and highly sensitive single element and multi-element APDs with associated ultra-low-noise ROIC (< 1 pA/rt-Hz) that far exceed the performance of similar products from other vendors.

   The Laser and Electro-Optics Branch is very familiar with the latest developments in microchip lasers and detector arrays with ROIC from all research and industrial entities. NASA technical personnel have attended the following conferences (that include vendor trade shows) over the last year:

   Photonics West 2008. San Jose, CA
   CLEO (Conference on Lasers and Electro-Optics) 2008 San Jose, CA
   Photonics West 2007. San Jose, CA
   CLEO (Conference on Lasers and Electro-Optics) 2007 Baltimore, MD

The Laser and Electro-Optics Branch has had personal interaction (including corporate site visits) with the following fiber laser/amplifier vendors: Aculight Inc., Northrop-Grumman, IPG Photonics, Neolight Inc., Fibertek Inc. The only company that can provide both transmitters and receivers suitable for this IIP application is Raytheon.

9. **Other facts supporting the use of other than full and open competition:**
While other companies such as Rockwell Scientific, Princeton Lightwave, Spectrolab, etc are doing similar work, Raytheon is the most advanced and most capable of meeting our requirement. Other DoD contractors such as Rockwell Scientific, Princeton Lightwave, SpectroLab, Lockheed Martin, Boeing, Ball Aerospace, etc. cannot meet the requirement because they concentrate their effort in LADAR areas in a different wavelength region (1.5 μm versus the 1 μm we proposed). The components and subsystems these companies concentrated on are different technologies and wavelength regime which are totally incompatible. They may be able to meet the single element laser and/or detector requirement, but definitely not the mutli-element monolithic array design needed for this program. To provide coverage of an area, these companies typically use opto-mechanical scanning mechanisms to steer the laser beam to a particular area of interest. The approach uses an array of lasers to provide a non-scanning coverage of an area and image the return light on a detector array that is of the same configuration. This eliminates any issues of mechanical failure and minimizes the power requirement thus making this system more efficient.

10. **Sources, if any, that expressed an interest in writing in the acquisition:**

A synopsis was posted for a total of 15 days on September 3, 2008, to solicit input from industry. No responses were received.

11. **The actions the Agency may take to remove or overcome any barriers to competition before any subsequent actions for the supplies or services required:**

There are no actions that the Agency can take to overcome any barriers. Raytheon owns all the intellectual property rights to the hardware developed. NASA will own unlimited rights to all scientific data obtained and collected during the IIP effort. NASA's GSFC will publish all data obtained, collected, and paid for under this contract. [redacted]. A competition will most likely be issued at such time when the announcement of opportunity for LIST becomes available. We will monitor the market for future technology development from other companies.

JOFOC Signature Page for Technology development of laser transmitter and detectors for the Efficient Swath Mapping Laser Altimeter Demonstration IIP

TECHNICAL OFFICER: I certify that the supporting data presented in the justification are accurate and complete.

Signature 2/12/09 Date

CONTRACTING OFFICER: I certify that this justification is accurate and complete to the best of my knowledge and belief.

Signature 2/12/09 Date

PROCUREMENT OFFICER:
(CONCURRENCE)

Signature 2/13/09 Date

GSFC COMPETITION
ADVOCATE:
(APPROVAL)

Signature 2/19/09 Date